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Chinese university students' knowledge and attitudes regarding forest bio-energy

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ABSTRACT

The present study examines Chinese university students' attitudes and knowledge regarding energy, specifically towards forest bio-energy in their country. The study was based on opinions of students from Northwest Agriculture and Forestry University (NWAFU) in China and it was conducted using a questionnaire completed by 441 students. The students' attitudes are seen as highly relevant because they are considered as both potential consumers and possible experts in the field of bio-energy. Their activities influence how the future energy markets will likely develop. The results revealed various interesting facets of the students' views regarding energy usage. Of particular interest is the students' positive attitude towards renewable energy in general, but slightly less positive towards forest bio-energy. However, the respondents expected to receive more information and knowledge about renewable energy and forest bio-energy. Moreover, it can be concluded that the dissemination of knowledge through different sources (e.g. teaching in school, information available on the Internet and other media channels) is an increasingly important aspect regarding energy issues. The results of this study can provide information of the perceptions of young educated people on energy policy issues and thus serve political decision-making processes for the future options concerning the development of forest bio-energy in China. Finally, the outcome of this study indicates that further environmental and energy education in China is urgently needed.

Contents

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1. Introduction

Traditionally wood and other types of forest biomass are widely used as private and industrial fuel in Asian countries [1], for example, it is the main source of energy for cooking and heating for hundreds of millions people, especially in the countryside. Biomass is often locally available and less expensive than other energy sources. The use of fuel-wood is a critical part of energy policies in many developing countries. In China, in 2004, 80% of the population relied on solid biomass fuels [2]. According to the Food and Agriculture Organization (FAO) [3] China's fuel-wood production was about 200 million cubic meters, corresponding to 67% of the country's total round-wood production in 2005. This has numerous social and environmental implications both nationally [1,4] and abroad [5] especially in the context of the national logging restrictions which were at the core of the Natural Forest Conservation Program (NFCP) of 1998 [6].

During recent decades the use of fuel-wood has changed from traditional to modern methods, especially in industrialized countries. New opportunities such as biomass pellets, liquid bio-fuels, and biomass power generation are available [7]. In addition, with technological development the conversion efficiency of fuel-wood has been greatly improved, especially in Europe [8]. China's development demands improvements in the utilization of energy sources and thus new and efficient ways of using renewable raw materials is becoming an increasingly important issue. Forests make an important contribution to bio-energy in China [9], as for example, the production of non-edible seeds and fruits, suitable for bio-fuels, are considered as important means for helping to meet fuel demand in the transport sector. In 2005, bio-ethanol accounted for 20% of the total gasoline consumption in China [10]. At present, 27 cities in nine provinces in China have started to use ethanol blended with gasoline for public transportation [10]. According to the Medium and Long-Term Development Plan for Renewable Energy in China [11], the use of biomass for energy has been rapidly increasing, with the priorities for biomass energy development being biomass power generation, biogas, biomass pellets, and liquid bio-fuels. The Chinese government has set a target that the bio-fuel sector will meet 15% of China's transportation energy needs by 2020 [11]. This is in the context of the growing issues facing China's environment resulting from its rapid economic development, including its growing demand for energy [12], thus underlining the potentially significant role that forests can play in China's future sustainable development.

Although the development of forest bio-energy[1] in China is important and has potential benefits, there are many constraints that may impede its use. These constraints include limited awareness of energy shortages and consequences of climate change, as well as poor knowledge of the potential of forest biomass regarding energy production [13]. On the one hand, to further develop the decision-making process, including assuring the applicability of the results, it is necessary to study the public's attitudes and knowledge regarding forest bio-energy. On the basis of understanding their attitudes and knowledge, it is possible to accurately define the constraints, and consequently to take them into account in the decision-making. On the other hand, the development of education materials and programs for different focus groups, such as forestry professionals, energy professionals, economic developers, as well as the general public can, for example, lead to improving the efficiency of current bio-energy operations, for instance, through improving the understanding of modern applications of wood energy and of their consequential benefits to the global climate that can improve the social acceptance of the new ways to use wood energy [7,14].

Many barriers which hinder the successful implementation of energy projects can be considered results of the lack of social acceptance, for example as seen in the UK [15]. However, the important role of social acceptance in the implementation of renewable energy projects was largely neglected until the 1980s in all countries [16]. Recent studies about local acceptance of renewable energy in Europe and the USA [17,18], have show that the public's acceptance can greatly influence energy political decision-making.

Previous research in Finland of consumer and farmers' opinions about various aspects of the use of wood as an energy source [19,20] showed that knowledge from different stakeholders regarding bio-energy helps to market bio-energy products based on the assumption that the more knowledgeable the consumers are on the subject the more positive are their attitudes. In addition, within the groups of stakeholders the role of young people as future consumers and decision makers can be regarded as significant.

In Germany a survey was conducted to identify students' attitudes towards the use of green power [21]. The students were likely to choose green energy, but they would like to make knowledge based decisions. However, in another survey, in the UK, the awareness among students of biomass as a renewable energy source was found to be low [15], while in Finland, research into school pupils' perception of bio-energy was also conducted, and the results showed that the majority had a critical perception of bio-energy [22].

As set out in Agenda 21 [23], education is a keystone of sustainable development, and this includes changing people's opinions and habits regarding their relationship with the environment, including influencing decision makers, which is vital for the successful introduction of new technologies. A problem is how to protect the environment and resources under the premise of achieving sustainable energy development, energy structure adjustment and optimization. The popularization of knowledge of renewable energy use is undoubtedly one important solution [24]. The increased use of renewable energy depends on people's awareness; therefore, education plays a significant role. In China this was underlined by the Renewable Energy Law of China which stated that renewable energy knowledge and technology should be popularized through education [25]. Therefore, education is a key tool in enhancing the social acceptability of bio-energy. However, previous work has highlighted the lack of graduate level programs in field of renewable energy, including bio-energy [26–28].

Although the above examples are from different countries, the overall view is that the perceptions of bio-energy or forest bio-energy have been mixed, both positive and negative. These surveys have been conducted based on the understanding that stakeholders attitudes towards, and perceptions of, bio-energy affect the

[1] Forest bio-energy refers to energy from woody biomass, fuel-wood forest (in Chinese Xin Tanlin), shrub forest, woody oil plants, SRF (Short Rotation Forest) energy crops, forest residues, and waste wood from forest industries.

biomass utilization projects and the implementation of related energy policies. It is relevant that a fundamental requirement for a successful policy implementation is based on understanding the public's perceptions, attitudes, and knowledge. When public opinion supports the utilization of renewable energy, it makes the implementation of renewable energy policy easier [29]. In this sense, public attitudes towards bio-energy can be studied by focusing on different groups as targets, such as: local consumers, non-governmental organizations, central and local governments, producers, and academic experts.

An additional and relevant group is the university forestry students. These students can be viewed as being future experts and decision-makers in the field of bio-energy or forest bio-energy, as well as consumers. However, there is a lack of published research regarding their knowledge and attitudes in the field of energy or bio-energy, let alone forest bio-energy. In this context the aim of this study is to assess university students' attitudes and knowledge towards energy, and especially towards forest bio-energy in China. The target group of this survey is university students studying at Northwest Agricultural and Forestry University (NWAFU) in Shaanxi Province, whose studies are directly or indirectly related to agriculture and forestry.

According to the authors' experience, most of the students from NWAFU proceed to work in a government department at the town or county level, in a related forestry department, or continue with post-graduate study after graduation. Therefore their attitudes could greatly indicate the development of the energy markets, the orientation of energy producers, and the consumers' choices in the future. NWAFU is one of the three Universities (together with Beijing Forestry University, Northeast Forestry University) which are supported by the State Forestry Administration and Ministry of Education [30]. Their opinions will also be used to advise the decisions made by policy-makers and business. The validity of surveying Chinese students' attitudes has been stressed in other work in this field, for example, a survey of university students in Beijing regarding views on environmentalism [31], and environmental awareness [32] emphasized the students as an indication of future trends in the country, for example, as future decision makers. Students' knowledge on the current energy policy in China is also evaluated in order to determine how their attitudes are related to their knowledge and education. Furthermore, their attitudes towards different information channels regarding energy issues are also considered, as it can be expected that in the future information distributed by means of media will be increasingly important in disseminating knowledge, also in making energy policy.

2. Material and methods

2.1. The study design

The principal data was collected using a structured questionnaire. The questionnaire was created based on previous studies [19–21,33,34]. In this study, the university students' attitudes and knowledge towards forest bio-energy and renewable energy in general were examined. The questionnaire consisted of four sections:

1. Social demographic data of the respondents;
2. Questions about students' attitudes towards energy issues, such as preferred future energy sources, and reasoning of choices of energy types to be consumed;
3. Questions regarding students' willingness to pay for forest bio-energy and renewable energy;
4. Questions about the diffusion of forest bio-energy information.

The written questionnaire was originally formulated in English and then translated into Chinese. Before the formal survey was conducted, a pilot survey was delivered to ten Chinese exchange students, studying at the University of Joensuu (Finland) in December 2008. The pilot survey in Chinese was also sent to three experts in China by email. Based on the responses to the pilot survey, small revisions were made, including the inclusion of additional questions. A definition of forest bio-energy and the aims of this survey were introduced to the participants at the beginning of the questionnaire.

In this study, the 5-point Likert scale was applied as an instrument for structuring and analyzing the answers, as previously used in related research in this field [19–21,33,34]. Attitudes towards forest bio-energy were measured in the questionnaire using the 5-point scale as follows: 1 (strongly disagree), 2 (disagree), 3 (not disagree, not agree), 4 (agree), 5 (strongly agree) or from 1 (not important at all) to 5 (very important).

The reliability of the 5-point Likert scale in the questionnaire was tested by using the Cronbach's alpha which showed a highly satisfactory level of internal consistency. A reliability coefficient of 0.70 and above is usually considered acceptable and desirable for consistency levels [22,35].

2.2. Participants and the data collection

The survey was conducted in March and April 2009 at the Northwest Agriculture and Forestry University (NWAFU) in Shaanxi Province, China. A representative sample of students at the University was surveyed. NWAFU is a comprehensive university with a strong specialization in agriculture, forestry, and related sciences. NWAFU is one of the top rated high level institutions for modern agricultural education in China, the only agriculture and Forestry University in Shaanxi Province, in addition to being one of the leading universities in the country. Among hundreds of master programs, only one graduate program entitled "Chemical Process Engineering of Forestry Products" is clearly related to bio-energy. Bachelor students in the college of forestry receive bio-energy information in dendrology. Generally speaking, the teaching of bio-energy is relatively minor [36]. To improve the development of forest bio-energy production and its utilization, as well as the forest bio-energy study curriculum in China, it is reasonable to study the students' knowledge and understanding of, as well as their attitudes towards, forest bio-energy at this University.

2.3. The analysis of data

The analysis included initial descriptive statistics, in order to compare the average ratings for the different statements. In addition, the ratings were crossed for the different demographic characteristics obtained in the first section of the questionnaire, in order to investigate possible explanatory variables. The variables considered were age, gender, area of origin (rural/urban), study subject and background. The analysis was based in classification trees based on Chi-squared tests, which allows the identification of differences between potential grouping factors. The significance values were based on adjusted *p*-values and significant differences were considered using the 0.05 threshold. In some cases, individual Chi-square test was used to isolate variables. All methods were performed using the statistical package SPSS v16.0.

3. Results

3.1. Social demographic information

A total of 464 questionnaires were delivered to university students in their classroom, with 441 completing the survey (95%

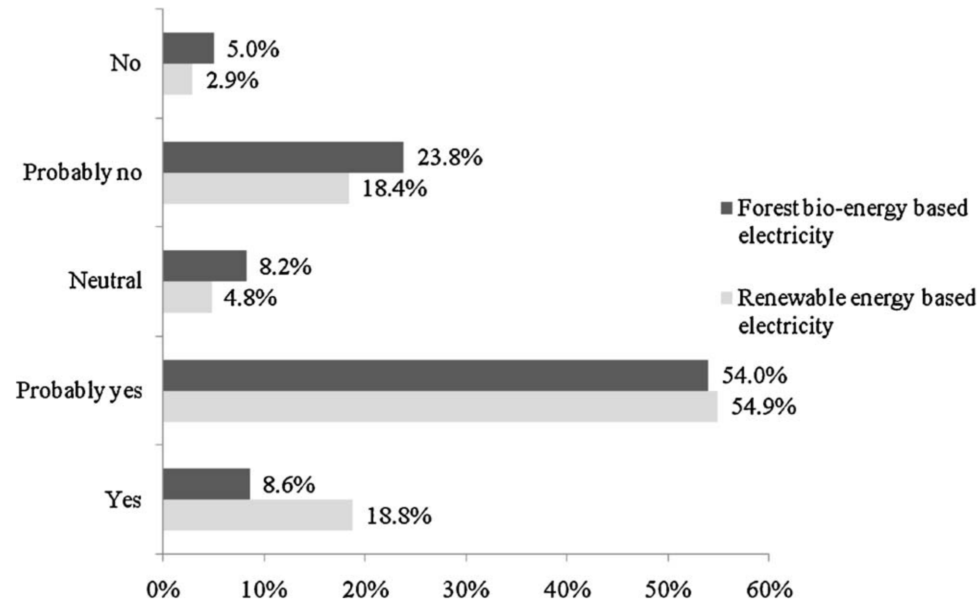


Fig. 1. The students' response to change their current non-renewable energy electricity into renewable energy and forest bio-energy even if that would cause any additional costs.

response rate). Most participants (82%) were from rural areas, with the remainder being from urban areas. Less than one-third (31%) were female students. The age of the respondents was between 18 and 28 years old (96% of the respondents were 19–23 years old). The respondents were from years one to four, in which 31% belong to year one, 48% year two, 17% year three, and 4% year four.[2] The students' background was divided into two groups: group 1 with background in forestry and agriculture consisted of 245 participants, and the second group with other academic backgrounds (including food sciences, biology, humanities, economics, ecology, water resources and architectural engineering) consisted of 195 participants. One respondent did not mention any academic background, and this answer was excluded from the calculations.

3.2. Attitudes towards renewable energy and forest bio-energy

3.2.1. University students' choice of their future heating and transportation energy source

A list of available energy types of future energy sources of heating and transportation was given to the participants. The participants were asked what would be their favorable energy sources of heating and transportation fuel in their daily lives in the future. Among the respondents the most favored future heating source was biogas (51.9%), while traditional uses of direct combustion of coal and firewood were the least favored energy sources for future heating. The most favored transportation fuel was hydrogen, 80.7% of the respondents chose this option. The least favored fuel was diesel (Table 1), followed by petrol.

Concerning heating, the background in forestry and agriculture was a significant factor when evaluating forest-bioenergy based electricity, as participants with a general forest and agriculture background preferred this option more than the rest (p-value < 0.001***). A more detailed analysis based on individual Chi-squared test by variables also found it to be a more favored option among students of forestry and agriculture (p-value = 0.018**). Neither gender nor family status influenced the choice of forest bioenergy based electricity. For the remaining alternatives for future heating, gender was a significant factor, as the male students preferred coal as a heating source (p-value = 0.006**), while females preferred wind power (p-value < 0.001***).

Table 1
Students' response to their future preferred heating and transportation fuel.

Preferred future heating	Percentage	Preferred future transportation fuel	Percentage
Biogas	51.9	Hydrogen fuel	80.7
Hydropower electricity	40.4	Blended petrol (10% ethanol)	21.8
Forest bio-energy electricity	37.4	Petrol	10.4
Wind power electricity	35.4	Diesel	6.6
Burning coal	14.3		
Burning firewood	12.7		

Concerning transportation fuels, hydrogen was the most preferred option in all groups, especially by females (p = 0.009) and males with background in forestry and agriculture (p = 0.048*). Disapproval of blended petrol was stronger among the female students (p-value = 0.017**).

3.2.2. University students' attitudes towards forest bio-energy and renewable energy

The participants were asked "Would you be willing to change your current non-renewable energy system to renewable energy based electricity or forest bio-energy based electricity even if that would cause additional costs?" More than a half of the respondents chose "probably yes" concerning the additional costs for using renewable energy or forest bio-energy (Fig. 1). The measure had a stronger support for renewable energy than for forest bio-energy based electricity (p-value < 0.001***). Different study backgrounds did not affect the willingness to change energy type to renewable energy or forest bio-energy based electricity. The only significant differences were found in renewable energy electricity, as the option "probably yes" was stronger among female students (p-value = 0.008**).

The students were willing to accept quite a high increase in the price of energy as a result of the switch to renewables (including forest bio-energy) (Table 2), with more than 50% willing to accept an increase of between 1 and 5%.

The participants were asked the reason why they would like to use renewable energy or forest bio-energy in their daily life.

[2] Universities in China provide 4-year Bachelor degree.

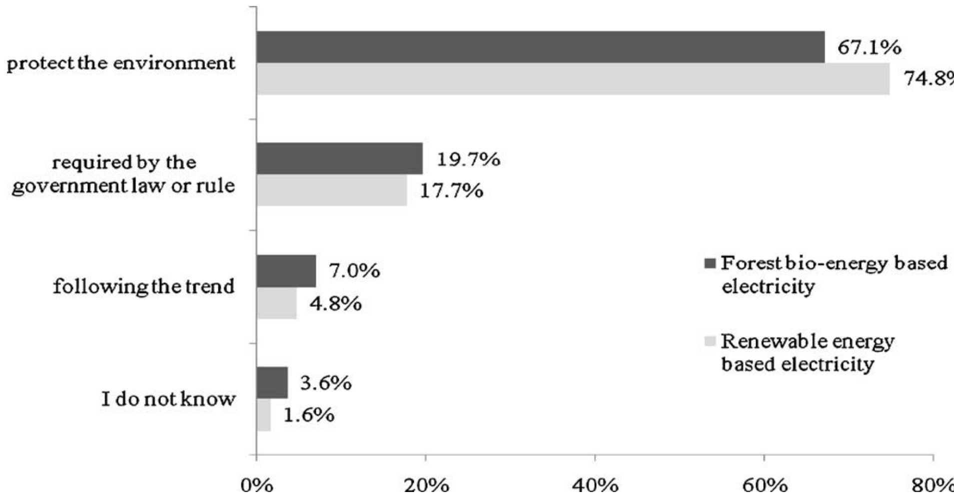


Fig. 2. Students' reasons why they would switch from traditional to forest bio-energy and renewable energy.

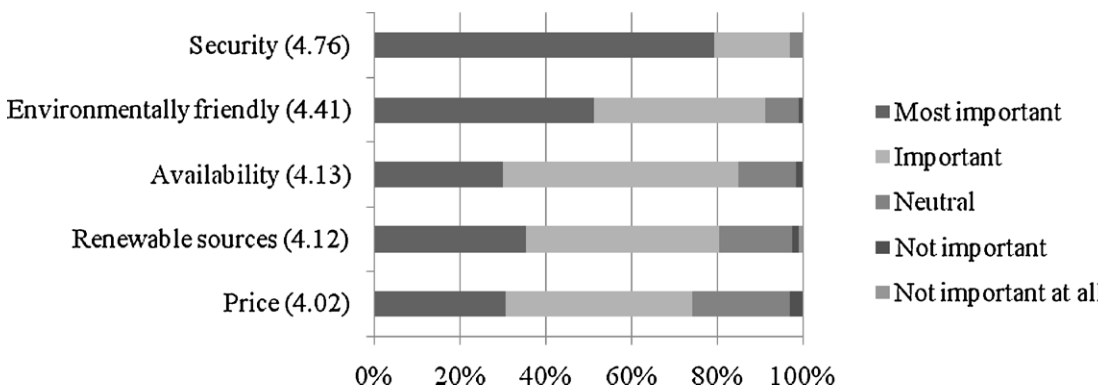


Fig. 3. The students' valuation of various properties of energy when choosing energy types. *Note*: the numbers in parenthesis are mean values of properties.

Table 2
Thresholds of additional costs that respondents were willing to pay to change their current non-renewable energy system for electricity.

	Renewable energy	Forest bio-energy
<1%	17.73%	20.59%
1–5%	57.73%	54.69%
6–10%	21.14%	19.68%
10–15%	3.18%	4.35%
>15%	0.23%	0.69%
Total	100%	100%

More than two-thirds of the respondents chose "protect the environment" as the most important reason, about 20% chose "required by the government law or rule". Some chose "following the trend" and "I do not know" (Fig. 2). Also in this case, the option renewable energy based has a stronger support than forest bio-energy based electricity (p-value = 0.012*).

The participants were asked which properties of energy are important when they choose energy types for their daily use. Almost 80% of the respondents considered the security of the energy source as the most important property. One half of the respondents valued the environmentally friendly nature of the energy source as the reason for their preference. "Price" was thought to be the least important aspect (Fig. 3). The students with a background in forestry and agriculture considered "environmentally friendly" (p-value = 0.003***) and "Renewable sources" (p-value = 0.006***) more important than the others. The students who came from rural areas manifested stronger support for "Availability" (p-value = 0.003***), especially when having a background in forestry and agriculture (p-value = 0.043*).

The students slightly agreed with the statement that forest bio-energy would be a major source of energy in the future. Statements about forest bio-energy were shown to the students and they were asked to rate the level of agreement with each statement (Table 3). The students had a positive attitude towards training and dissemination of information on forest bio-energy. They strongly supported the idea to teach forest bio-energy related subjects at the school level.

3.3. Information dissemination, knowledge, and understanding

According to the survey, most (75.5%) respondents had heard about forest bio-energy. Group 1[3] (forestry and agriculture background) were more aware of forest bio-energy compared to Group 2 (p-value = 0.01*). The knowledge and information acquisition part of the survey consisted of two general questions. First the students were asked "Does China have a *Renewable Energy Law*?" and second the students were asked "Have you ever read *Renewable Energy Law of China*?" For the first question, a little more than a quarter (27%) of the respondents answered "yes", while nearly 10% answered "no" and almost two-thirds (63.3%) answered "I do not know". Male respondents answered "Yes" more often than female respondents. For the second question, a small proportion (3.9%) of the respon-

[3] Group 1 refers to the respondents with a forestry and agriculture background. Group 2 refers to the respondents without a forestry and agriculture background.

Table 3
Level of students' agreement regarding statements concerning forest bio-energy (5 = strongly agree to 1 = strongly disagree) A&F = agriculture and forestry.

Statements	Mean value	Explanation
It is necessary to teach forest bio-energy based subjects from school level	4.15	i. 81.7% of respondents agreed with the statement (of which 33.6% agreed strongly) ii. 15.9% of the respondents chose neutral for this statement iii. Only 1.4% disagreed with this statement iv. Gender, academic background, or family status did not influence the level of agreement
I would be happy to educate and encourage people to get more knowledge about forest bio-energy	4.02	i. 75.5% of the respondents agreed (of which 27% agreed strongly) ii. 22.7% chose neutral iii. 0.9% disagreed with this statement iv. Students with the A&F background agreed significantly most often v. Gender or family status did not influence the level of agreement
It is justifiable to support the development of forest bio-energy	4.00	i. 78.9% agreed with this statement ii. 17.9% chose neutral iii. 2.1% disagreed
Increased use of forest bio-energy can mitigate the environmental problems	3.99	i. 75.3% agreed with this statement ii. 19% chose neutral iii. 4.7% disagreed
Forest bio-energy will be a major source of bio-energy in 10 years	3.26	i. 34.4% of the respondents agreed with this statement (of which 8.8% agreed strongly) ii. Almost half (48.3%) chose neutral iii. 15.9% disagreed iv. Students with the A&F background agreed significantly most often v. Gender or family status did not influence the level of agreement

dents answered "Yes". Academic background, gender, and family status did not influence the answer.

The students were asked from which sources they had received information about forest bio-energy and related matters. 41% of the respondents stated that the most important information source was the current survey, while 40.8% felt it to be their education. Group 1 selected "Education" more often than Group 2. The least important sources were friends/relatives (4.3%), and energy companies (3.2%).

In addition, the participants were asked to rank the importance of the possible information sources with respect to their influence on the students' opinions regarding forest bio-energy. Clearly the most appreciated source was television, with radio having the lowest ranking (Fig. 4).

4. Discussion

4.1. The opinion-formation of University students regarding renewable energy issues

On the basis of the results, the students oriented positively towards the use of renewable energy in general and specifically towards the increasing possibilities of utilizing bio-energy. The future visions of students were quite optimistic, though this is based on the high appreciation of technologies such as hydrogen which is not yet available for practical applications. They also accepted forest biomass based electricity as an environmentally friendly alternative source in heating much better than traditional firewood. Chinese university students seem to think similarly to their peers in other countries [22,37]. This study showed that students' attitudes were positive towards renewable energy in general, but slightly less positive towards forest bio-energy. Students slightly agreed that forest bio-energy would be a major source of energy in the future. The result is similar to the opinion of Chinese bio-energy experts [38].

It is of value to consider the results of the survey in the context of the general environmental awareness in China, with previous surveys giving a mixed message [39,40], which are likely a reflection of the changes in the Government's approach to environmental issues [41]. This process includes the increased emphasis on the inclusion of renewables in the energy portfolio [42]. This also underlines the importance of monitoring the development of perceptions of bioenergy as the government steps up its renewable energy programs.

4.2. University students' attitudes towards renewable energy and forest bio-energy

In the present study the attitudes towards renewable energy and forest bio-energy were quite similar among the respondents. According to the results, university students preferred renewable energy, especially biogas, in their future daily energy consumption. Most respondents in this study were from rural areas, and had received practical and concrete information about biogas in heating or cooking from home. Biogas is seen as being safe, clean, and convenient in everyday use and has a long history in China [42,43] hence the highly positive attitudes.

The strong preference for hydropower is understandable due to the strong government policy. Hydropower accounts for 6.7% of the total energy production and the installed capacity ranked as the first in the world [44]. The Three Gorges project is the biggest hydropower project in the world, and this information has been efficiently distributed through different media channels, such as TV programs, the Internet, and newspapers [41]. It can be concluded that most people in China are well aware of hydropower.

According to the results, the third top-rated heating source was forest bio-energy based electricity. At present, due to the shortage of raw materials, low technological development, inadequate industrial standards and production systems, as well as the absence of specific forest biomass energy policy, the industrial development of forest bio-energy plants in China has been slow [45]. Therefore, this might explain why the acknowledgment of forest bio-energy is much lower than biogas.

Furthermore, half of the respondents felt that they were willing to use renewable energy or forest bio-energy. They were aware of the benefits of so called green energy. However the students agreed

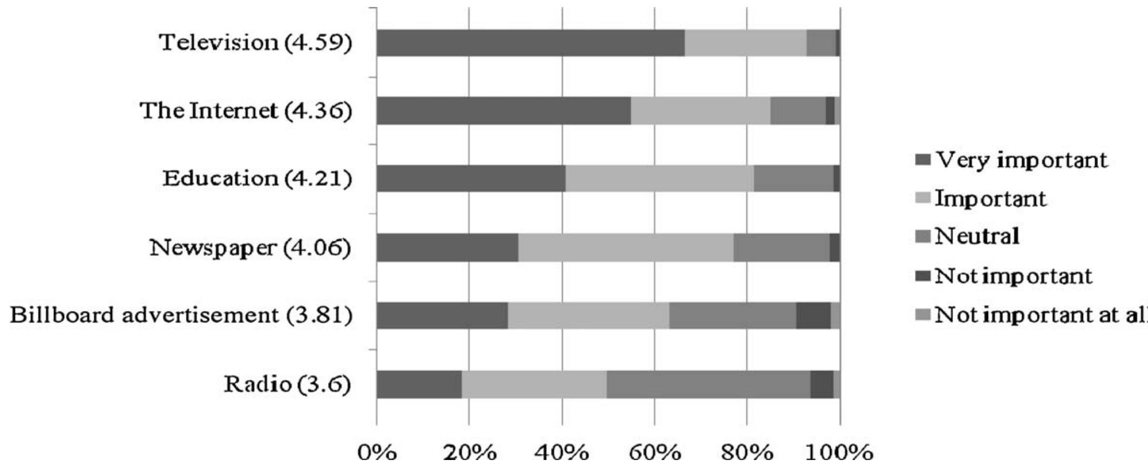


Fig. 4. Students' attitudes towards the various information channels. *Note*: the numbers in parenthesis refer to the mean values.

that there is a lack of fundamental knowledge, such as regarding generation, distribution, advantages and potential problems in the utilization of green energy power technology. This may be a reflection of the comparatively limited focus given by the government towards forest bio-energy compared to other sources of bio-energy, especially in the context of the important role that government plays in people's everyday lives in China.

4.3. Knowledge acquisition and information diffusion

The research findings show a low level of knowledge among the students about forest bio-energy, with the conclusion that specific attention should be paid to these issues in forestry education in China. The concept of forest bio-energy was found to be moderately familiar among the students with an agriculture and forestry background. They have better opportunities than the others to participate in courses with bio-energy relevant contents. A large majority (82%) of the respondents agreed that it is necessary to teach forest bio-energy related subjects in schools. This implies that students appreciate the opportunity to learn new things about forest bio-energy. Students expect that the university can provide systematic teaching on bio-energy categories and generation mechanisms. Previous studies assessing renewable energy education in Serbia, Montenegro, and Turkey, showed similar results. The overall views were considered unsatisfactory and the education of renewable energy should be expanded and strengthened [27,28]. Therefore, active and comprehensive teaching about renewable energy and forest bio-energy will be beneficial for students' future life. This will prove important with regards to the students spreading knowledge about bio-energy to the general public as a whole, thereby generating support and facilitating acceptance.

According to the results, the students' knowledge about the policy development of renewable energy in China was moderate. Therefore the education has to contain critical elements, both to improve possibilities for understanding how the public's perceptions of renewable energy are formed, and what is the basis of attitudes. From this basis it becomes realistic to increase awareness on its possible use. In terms of sustainability, the share of renewable energy has to be increased in the total energy production [46].

Knowledge and attitudes regarding renewable energy and forest bio-energy appeared to be influenced by gender. Male respondents knew more about renewable energy issues than female respondents and male perceptions seem to be more aware of reality on this issue than their female counterparts. This implies men have a greater interest or involvement in the field of renewable energy than women. A challenge is to increase the interest of women in these issues because their role in the daily consumption of energy is as important as men. In general, the level of basic knowledge or information of forest bio-energy did not vary between the different academic background groups, and this similarity can be considered due to the limited subjects provided by the universities. The environmental awareness of university students is likely to be higher than in the less educated social groups, but overall the possibilities of acquiring and installing renewable energy in practice are still in a relatively nascent stage in China. These possibilities play an important role in the acceptance and understanding of forest bio-energy sources and equipment in society [47,48]. The more information is distributed, the more the options customers may have. Then it becomes possible for them to accept new types of energy tools. Therefore the information diffusion is an important aspect in the implementation of the new energy equipment [49]. From a broad perspective, political bodies have their roles in removing barriers which hinder the use of new renewable energy systems as well as in creating, restructuring, and supporting competitive renewable energy markets for the benefit of the sustainability of the economy, environment, and society.

Students actively participated in this survey (95% response rate) with most of them agreeing that the survey provided useful knowledge and information about the development of forest bio-energy. In general, the students seem to have had limited opportunities to receive information about forest bio-energy, and in fact showed interest in receiving information from multiple sources (e.g. television, the internet, newspapers and books). This lack of information availability differs from previous studies performed in other countries. For example, in Devon (UK) the local newspaper was considered to be the most preferred source [18]. Another example is Braunholtz's [50] finding that especially in the rural areas, local newspapers play a significant role, while more generally, TV is the main channel of information regarding renewable energy issues in Scotland [50]. It is understandable that the students surveyed felt that the most common information source is education, which disseminates knowledge and information to them. The Internet is highly accessible, and provides rich content, and popular information. It plays an important role in the distribution of information and in education in bio-energy issues [34,51]. To make forest bio-energy familiar as a reasonable choice it should be handled in an appropriate manner in education. The availability of the Internet in the universities is presently very high but access to other media, such as TV and newspapers needs to be improved. Furthermore, the study curriculum needs to be developed with material on forest bio-energy issues to improve the opportunities of the future citizens and experts in the field of forest bio-energy policies.

5. Conclusions

The present study showed that university students' attitudes are positive towards renewable energy in general and especially towards bio-energy, but less positive towards forest bio-energy. University students' attitudes implied the importance of the forest bio-energy information given by different media channels, which are increasingly promoted in China. The role of education is significant, but it has to be taken into consideration that currently people become educated by formal and informal means and through different information channels, and knowledge is not only given in the classroom. However, the Internet plays now an important role and contains possibilities for increasing awareness of how to consume renewable energy. This is meaningful when thinking about how people live regarding the use of energy. In this way it can be seen how the strategies for implementing sustainable development work both locally and globally. The results of this survey provide evidence on the knowledge acquisition for renewable energy policy choices, and this way help political decision-making processes for the future development of forest bio-energy in China. Finally, this study indicates that education and information concerning renewable energy and especially forest bio-energy have to be developed in the Universities in China.

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References

[1] Chen L, Heerink N, Berg M. Energy consumption in rural China: a household model for three villages in Jiangxi Province. Ecol Econ 2006;58:407–20.
[2] EarthTrends: population, health and human well-being public health: solid fuel use, http://earthtrends.wri.org/text/population-health/variable-1298.html; 2004 [retrieved at: 27.08.09].
[3] FAO, Food and Agriculture Organization of the United Nations, http://www.fao.org/forestry/country/57025/en/chn/; 2007 [retrieved at: 02.05.11].
[4] Smith KR. Health impacts of household fuelwood use in developing countries. Unasylva 2006;244:41–4.
[5] Laurance WF. The need to cut China's illegal timber imports. Science 2008;319:1184–6.
[6] Zhao G, Shao G. Longging restrictions in China: a turning point for forest sustainability. J Forest 2002;4:34–7.
[7] Stupak I, Asikainen A, Jonsell M, Karltun E, Lunnan A, Mizaraite D, et al. Sustainable utilization of forest biomass for energy – possibilities and problems: policy, legislation, certification, and recommendations and guidelines in the Nordic, Baltic, and other European countries. Biomass Bioenerg 2007;31:666–84.
[8] Richter Jr D, Jenkins DH, Karakash JT, Knight J, McCreery LR, Nemestothy KP. Wood energy in America. Science 2009;29:1432–3.
[9] Gan L, Yu J. Bioenergy transition in rural China: policy options and co-benefits. Energ Policy 2008;36:531–40.
[10] Wu CZ, Yin XL, Yuan ZH, Zhou ZQ, Zhuang XS. The development of bioenergy technology in China. Energy 2009;35(11):4445–50.
[11] NDRC, National Development and Reform Commission People's Republic of China. Medium and long-term development plan for renewable energy in China (Abbreviated version, English Draft); September 2007.
[12] Liu J, Diamond J. China's environment in a globalizing world. Nature 2005;435(30):1179–86.
[13] Lv W, Wang CF, Wang GS, Yu GL, Zhang CH, Zhang DH, et al. Study on potential investigation of wood biomass resources in China. China Energy 2005;27(11):21–6.
[14] Mayfield CA, Foster CD, Smith CT, Gan JB, Fox S. Opportunities, barriers, and strategies for forest bioenergy and bio-based product development in the Southern United States. Biomass Bioenerg 2007;31:631–7.
[15] Devine-Wright P. Reconsidering public attitudes and public acceptance of renewable energy technologies: a critical review. A working paper of the research project "Beyond Nimbyism: a multidisciplinary investigation of public engagement with renewable energy technologies" funded by the ESRC under the 'Towards a Sustainable Energy Economy' Programme. Working paper 01.04.07.
[16] Wustenhagen R, Wolsink M, Burer MJ. Social acceptance of renewable energy innovation: an introduction to the concept. Energ Policy 2007;35: 2683–91.
[17] Agterbosch S, Glasbergen P, Vermeulen WJV. Social barriers in wind power implementation in The Netherlands: perceptions of wind power entrepreneurs and local civil servants of institutional and social conditions in realizing wind power projects. Renew Sust Energ Rev 2007;11:1025–55.
[18] Upham P, Shackley S. Local public opinion of a proposed 21.5MW(e) biomass gasifier in Devon: questionnaire survey results. Biomass Bioenerg 2007;31:433–41.
[19] Rämö AK, Toivonen R, Tahvanainen L, Silvennoinen H. Energiaa puustakuluttajien käsitykset puun energiakäytöstä. (Energy from wood: perceptions of consumers towards energy use of wood) Pellervon taloudellisen tutkimuslaitoksen työpapereita. Helsinki, helmikuu 2002 [in Finnish].
[20] Silvennoinen H, Latvala T, Järvinen E, Toivonen R, Römö AK, Pelkonen P. Bioenergiaa metsistä ja pelloilta: viljelijöiden suhtautuminen bioenergiaraaka-aineiden tuotantoon ja tarjontaan sekä bioenergiayrittäjyyteen. (Bioenergy from forests and fields: the attitude of farmers towards the production and supply of bioenergy raw materials and towards bioenergy related entrepreneurship), Pellervon taloudellisen tutkimuslaitoksen raportteja 211. 2008 [in Finnish].
[21] Gossling A, Kunkel T, Schumacher K, Heck N, Birkemeyer J, Froese J, et al. A target group-specific approach to "green" power retailing: students as consumers of renewable energy. Renew Sust Energ Rev 2005;9(1):69–83.
[22] Halder P, Pietarinen J, Havu-Nuutinen S, Pelkonen P. Young citizens' knowledge and perceptions of bioenergy and future policy implications. Energ Policy 2010;38:3058–66.
[23] Agenda 21. Programme of action for sustainable development. Promoting education, public awareness and training. New York: United Nations Publications; 1992 [Chapter 36].
[24] Jennings P, Lund C. Renewable energy education for sustainable development. Renew Energ 2001;22:113–8.
[25] NPC, National People's Congress. Renewable energy law of People's Republic of China. In: Adopted at the 14th session of the Standing Committee of the 10th National People's Congress. 2005.
[26] Remedio EM. Sustainable forestry and wood energy education: a crisis in pedagogy. CII World Forestry Congress, http://www.fao.org/DOCREP/ARTICLE/WFC/XII/1042-C4.htm; 2003 [retrieved at: 02.05.11].
[27] Bojic M. Education and training in renewable energy sources in Serbia and Montenegro. Renew Energ 2004;29:1631–42.
[28] Karabulut A, Gedik E, Kecebas A, Alkan MA. An investigation on renewable energy education at the university level in Turkey. Renew Energ 2011;36:1293–7.
[29] Van Dijk A, Beurskens L, Boots M, Kaal M, De Lange T, Van Sambeek E, Uyterlinde M. Renewable Energy Policies and Market Developments. ECN-Energy Research Centre of the Netherlands, March, ECNC03-029.2003.
[30] Chinanews, http://www.chinanews.com/edu/2010/11-29/2688498.shtml; 2010 [retrieved at: 02.05.11].
[31] Stalley P, Yang D. An emerging environmental movement in China? Chin Quart 2006;186:333–56.
[32] Wong KK. The environmental awareness of university students in Beijing, China. J Contemporary China 2003;12(36):519–36.
[33] Ek K. Public and private attitudes towards "green" electricity: the case of Sweden wind power. Energ Policy 2005;33:1677–89.
[34] Qu M, Tahvanainen L, Ahponen P, Pelkonen P. Bio-energy in China: content analysis of news articles on Chinese professional Internet platforms. Energ Policy 2009;37:2300–9.
[35] Prokop P, Prokop M, Tunnicliffe SD. Is biology boring? Student attitudes toward biology. J Biol Educ 2007;42(1):36–9.
[36] NWSAF (North West Agriculture and Forestry University), General information, http://en.nwsuaf.edu.cn/html/About_A_F/General_Information/20080226/2.html; 2010 [retrieved at: 20.06.10].
[37] Greenberg M. Energy sources, public policy, and public preferences: analysis of US national and site-specific data. Energ Policy 2009;37:3242–9.
[38] Qu M, Ahponen P, Tahvanainen L, Pelkonen P. Chinese academic experts' assessment for forest bio-energy development in China. Energ Policy 2010;38(11):6767–75.
[39] Feng Z, Wang X. Survey and evaluation on residents' environmental awareness in Jiangsu Province of China. Int J Environ Pollut 2002;17(4):312–22.
[40] Wu Y. Deregulation and growth in China's energy sector: a review of recent development. Energ Policy 2003;31:1417–25.
[41] Xie L, van der Heijden HA. Environmental movements and political opportunities: the case of China. Social Movement Studies 2010;9(1):51–68.
[42] Chen Y, Yang GH, Sweeney S, Feng YZ. Household biogas use in rural China: a study of opportunities and constraints. Renew Sust Energ Rev 2010;14:545–9.
[43] Zhang PD, Jia GM, Wang G. Contribution to emission reduction of CO_2 and SO_2 by household biogas construction in rural China. Renew Sust Energ Rev 2007;11:1903–12.
[44] Huang HL, Yan Z. Present situation and future prospect of hydropower in China. Renew Sust Energ Rev 2009;13:1652–6.
[45] Zhang PD, Yang YL, Tian YS, Zhang YK, Zheng YH, Wang LS. Bioenergy industries development in China: dilemma and solution. Renew Sust Energ Rev 2009;13:2571–9.
[46] Deng AP, Han XT, Xie J, Pu SX. The effect of renewable energy universal education in China. J Hebei Energy Inst Vocat Technol 2008;2:30–2.

[47] Stern PC. Blind spots in policy analysis: what economics does not say about energy use. J Policy Anal Manag 1986;5:200–27.
[48] Reddy S, Painuly JP. Diffusion of renewable energy technologies – barriers and stakeholders' perspectives. Renew Energ 2004;29:1431–47.
[49] Roos A, Rakos C. The limits of modeling. Experiences with bioenergy in practice – could models have predicted this outcome? Biomass Bioenerg 2000;18:331–40.
[50] Braunholtz S, Public Attitudes to Windfarms: a survey of local residents in Scotland, Scottish Executive, Social Research, MORI Scotland, http://www.scotland.gov.uk/library5/environment/pawslr.pdf; 2003 [retrieved at: 05.05.11].
[51] Mara KL, Jennings PJ. Innovative renewable energy education using the World Wide Web. Renew Energ 2001;22:135–41.